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54 Self-loading air bearing slider.

57 A self-loading air bearing slider comprises: a body having a leading edge (12) and a trailing edge; a pair of spaced-apart side rails (16,18) disposed along the side edges of a surface of the body; and a cross rail (20) disposed laterally across the surface of the body joining the side rails. The side rails define a recessed section (22) trailing the cross rail (20), the recessed section being closed on three sides by the rails (16,18,20). Vents (38) are disposed at the trailing edge of the side rails (16,18) allowing the recessed section (22) to communicate with ambient gas pressure. The arrangement is such that, in operation, a negative pressure region is established at the recessed section, while positive pressure regions are established at the side rails (16,18) whereby the slider can fly in close proximity to a confronting planar surface at a substantially constant flying height.

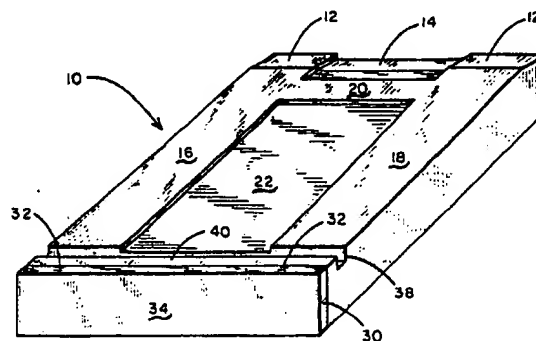


Fig. 2

EP 0 277 414 A2

SELF-LOADING AIR BEARING SLIDER

This invention relates to self-loading air bearing sliders for magnetic head assemblies.

Magnetic head assemblies that fly relative to magnetic disks have been used extensively. The objectives for improving the transducing relationship between the magnetic head assembly and a magnetic disk include a close spacing between the magnetic head assembly and the disk, and to maintain such spacing at a constant flying height. Close spacing, when used with very narrow transducing gaps and very thin magnetic recording films, allows short wave-length, high-frequency signals to be recorded, thereby affording high density, high storage capacity recording.

In accessing disks, for example, the flying height of a magnetic head assembly varies as the magnetic head assembly is moved radially to different data tracks because the angular velocity of the rotating disk at the outer tracks is greater than that at the inner tracks. Maintaining a near constant flying height over the surface of the disk is desirable because it allows the average flying height from inner to outer radius to be reduced thus allowing a higher storage density without reducing reliability.

One way of providing for a near constant flying height is to use a self-loading negative pressure air bearing slider. By providing a negative pressure air bearing slider as described in US-A-4,475,135 differences in air track speed between an inner and outer track on a rotating disk cause compensating changes in the positive and negative pressures on the air bearing slider which result in a near constant flying height.

The manufacture of a negative pressure air bearing slider designed to fly at very low flying heights relative to the surface of a disk is difficult. A process which provides repeatable, physical dimensions of the negative pressure air bearing slider and employs a laser is disclosed in pending United States Patent Application No. 910593. In the known process, machining by various means must be made to a trailing edge of the air bearing slider. The machining employed must remove material from a thin film magnetic transducer assembly.

The present invention seeks to provide a self-loading air bearing slider which eliminates the need to machine material from a thin film magnetic transducer assembly.

According to the present invention there is provided a self-loading air bearing slider comprising: a body having a leading edge and a trailing edge; a pair of spaced-apart side rails disposed along the side edges of a surface of the body; and a cross rail disposed laterally across the surface of the

body joining the side rails; the side rails defining a recessed section trailing the cross rail, the recessed section being closed on three sides by the rails, characterised by vent means disposed at the trailing edge of the side rails allowing the recessed section to communicate with ambient gas pressure, the arrangement being such that, in operation, a negative pressure region is established at the recessed section, while positive pressure regions are established at the side rails whereby the slider can fly in close proximity to a confronting planar surface at a substantially constant flying height.

In one embodiment the vent means comprises a pair of side vents disposed near the trailing edge of the side rails to allow the recessed section to communicate with ambient gas pressure, the side vents being formed at an acute angle to the side rails.

The air bearing slider may include a pair of notches disposed in the side rails in close proximity to the vent means to relieve positive pressure from the leading portion of the side rails adjacent to the vent means.

A leading edge portion of the body may be tapered.

The side rails and cross rail preferably define a relatively deep recessed section disposed towards the leading edge of the body.

The body may be rectangular in plan. Preferably the flying height relative to said confronting planar surface is in the range of 8×10^{-5} to 2.8×10^{-4} mm (3×10^{-5} to 1.1×10^{-4} inch).

The recessed section may have a depth relative to the surfaces of the rails (16,18,20) of 5×10^{-4} to 3×10^{-2} mm (2×10^{-5} to 1.2×10^{-3} inch).

In one embodiment a trailing edge cross rail comprises a plurality of transducer elements for addressing tracks on the confronting planar surface. The trailing edge cross rail may provide a full width close proximity sensor of media roughness on the confronting planar surface.

Preferably the positive pressure and negative pressure regions provide a net load of substantially zero across the surface of the body.

It is to be noted that the use of the terms "positive pressure" and "negative pressure" in this specification means pressure relative to ambient pressure. The ambient gas need not be air but refers to the gas medium surrounding the air bearing slider.

Preferably a self-loading air bearing slider according to the present invention provides good stability by having a high stiffness requiring a large force to move it in an up or down direction, retains

the characteristics of a near constant flying height, and does not require machining in the region of the transducer assembly.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:-

Figure 1 is a perspective view of a known negative pressure air bearing slider;

Figure 2 is a perspective view of one embodiment of a self-loading air bearing slider according to the present invention;

Figures 3a and 3b are top plan views of two further embodiments of a self-loading air bearing slider according to the present invention; and

Figure 4 is a graph showing both flying height and slope versus disk speed for self-loading air bearing sliders according to the present invention.

Throughout the drawings like parts have been designated by the same reference numerals.

Figure 1 shows a known negative pressure air bearing slider 10 formed from a substantially rectangular block of ceramic material such as ferrite. The slider 10 is shown having a body with a leading edge taper 12 and a stepped leading cavity 14. Side rails 16,18 extend along the length of the body of the air bearing slider.

Connecting the side rails is a cross rail 20. The side rails and the cross rail form a substantially coplanar surface. The three rails enclose a recessed cavity 22 which forms a trailing cavity. At the trailing edge of the body of the air bearing slider is a thin film transducer assembly 30. This transducer assembly can be integrally formed on the body of the air bearing slider or be attached by glue or glass bonding prior to machining of a surface of the air bearing slider. Pole tips 32 are the transducer elements for which a close disk spacing is desired. The pole tips lie in the same plane as the side rails 16,18.

The leading and trailing cavities can be machined, chemically etched, formed by ion milling, or preferably laser machined as disclosed in U.S. Patent Application No. 910,593. In laser machining, particularly with a Nd:YAG laser, ceramic materials like ferrite and aluminium oxide/titanium carbide composites are easily machined whereas thin film deposits of pure aluminium oxide do not as easily absorb the laser energy and vapourise. An oxide layer 32 used for encapsulation of the thin film transducer assembly 30 tends to chip or crack easily and thus is not compatible with laser machining under the same operating conditions useful for the ceramic materials. In the known negative pressure air bearing slider of Figure 1, the oxide and other materials have been removed in the area indicated by reference numeral 36, so that any ceramic material need be machined at the time the recessed cavity 22 is formed. The selective

removal of the oxide layer 34 requires a separate photomask operation followed by chemical etching, ion milling, or reverse mask lift-off of the area 36.

Figure 2 shows a self-loading air bearing slider 10 according to the present invention. Like parts in Figures 1 and 2 have been designated by the same reference numerals and will not be described in further detail. Machined near the trailing edge of the body of the air bearing slider 10 is a side vent groove 38. The side vent groove must be sufficiently large so that when the air bearing slider is flying above a magnetic disk, the air that passes between the air bearing slider and the surface of the magnetic disk can freely flow to either side of the air bearing slider through the side vent groove 38, and the negative pressure within the recessed cavity 22 would not be affected. The minimum size for the side vent groove 38 is of the order of 0.10mm (0.004 inch) in width by about 0.05mm (0.002 inch) in depth. The actual cross sectional shape of the side vent groove 38 need not be rectangular. The primary requirement is that its cross sectional area be sufficient so that air flow within it is not significantly restricted. Rearward of the side vent groove is a trailing edge cross rail 40 which is made up of a sufficient portion of the body of the air bearing slider 10 adjacent to the transducer assembly 30 to support it mechanically. The width of the trailing edge cross rail 40 is kept to a minimum, being approximately 0.08mm (0.003 inch) to 0.13mm (0.005 inch) wide to retain known desirable features of a negative pressure air bearing slider. The surface of the trailing edge cross rail 40, and the pole tips 32 are coplanar with the side rails 16,18 and the cross rail 20.

The use of the side vent groove 38 avoids the need for the selective removal of the oxide layer 34 from the transducer assembly 30 as shown by the area 36 while preserving the basic characteristics of the negative pressure air bearing slider. The self-loading air bearing slider of Figure 2 can be cut by a laser with no damage to the transducer assembly 30. Since the trailing edge is not cut there is no need to tilt the parts or perform a double alignment of the air bearing slider during machining. The entire trailing edge flies at close proximity to a magnetic disk and that provides more area for multiple head transducer structures. The design does not preclude the use of ion milling or chemical etching in the manufacturing process of the air bearing slider. It is expected that the side vent groove 38 may be also implemented by conventional diamond saw cutting methods. Since the entire width of the trailing edge of the air bearing slider can be made to fly in close proximity to the surface of the disk, this design can be more effective in a media screening test (referred to as a Flying Integrity Test or FIT test) as a low flying

detector of bumps, asperities or imperfections on the surface of a magnetic disk.

Shown in Figure 3a is an alternative embodiment of a self-loading air bearing slider according to the present invention where the recessed cavity 22 has angled side vent openings 42 and a triangular trailing edge cross rail or bar 44. The vent openings 42 may be tapered and the actual angles and break points may vary over a wide range. Figure 3a shows the width of each side vent 42 being greater than the width of the side vent groove 38 shown in Figure 2, but having a depth the same as that of the recessed cavity 22. This embodiment may provide greater ease of processing.

Another embodiment of a self-loading air bearing slider according to the present invention is shown in Figure 3b and has a deep side vent notch 46 in each side rail 16,18 to aid in the reduction of positive pressure from going into the side vent groove 38. Positioning of the notches 46 relative to the side vent groove 38 also offers some control in the balance of positive and negative forces on the air bearing slider which affect the flying height versus speed response of the air bearing slider. The side vent notch 46 reduces the positive pressure of the side rails before the positive pressure reaches the side vent groove 38. This can help the side vent groove in providing a sub-ambient pressure within the recessed cavity 22.

Figure 4 illustrates by curve 50 the near constant flying height of a self-loading air bearing slider according to the present invention at different speeds of rotation of a magnetic disk. Curve 52 shows the slope of the slider as a function of speed of the rotation of the disk. The slope or pitch defined on the right vertical axis is a measure of the difference in flying height of the leading edge over the trailing edge for the air bearing slider given in microinches per inch ($\mu\text{in/in}$). The results shown in Figure 4 are for an air bearing slider having the construction shown in Figure 2 with the side vent being 0.24mm (0.0096 inch) wide and approximately 0.05mm (0.002 inch) deep.

What has been developed is a self-loading air bearing slider for supporting a transducer assembly which air bearing slider can be easily machined and manufactured yet retains the desired features of a negative pressure air bearing slider having near constant disk to transducer assembly flying height over a wide range of disk speeds.

Claims

1. A self-loading air bearing slider comprising: a body having a leading edge (12) and a trailing edge; a pair of spaced-apart side rails (16,18) dis-

posed along the side edges of a surface of the body; and a cross rail (20) disposed laterally across the surface of the body joining the side rails; the side rails defining a recessed section (22) trailing the cross rail (20), the recessed section being closed on three sides by the rails (16,18,20), characterised by vent means (38;42) disposed at the trailing edge of the side rails (16,18) allowing the recessed section (22) to communicate with ambient gas pressure, the arrangement being such that, in operation, a negative pressure region is established at the recessed section, while positive pressure regions are established at the side rails (16,18) whereby the slider can fly in close proximity to a confronting planar surface at a substantially constant flying height.

2. An air bearing slider as claimed in claim 1 characterised in that the vent means comprises a pair of side vents (42) disposed near the trailing edge of the side rails (16,18) to allow the recessed section (22) to communicate with ambient gas pressure, the side vents being formed at an acute angle to the side rails (16,18).

3. An air bearing slider as claimed in claim 1 or 2 characterised by a pair of notches (46) disposed in the side rails (16,18) in close proximity to the vent means (38;42) to relieve positive pressure from the leading portion of the side rails adjacent to the vent means.

4. An air bearing slider as claimed in any preceding claim characterised in that a leading edge portion (14) of the body is tapered.

5. An air bearing slider as claimed in any preceding claim characterised in that the side rails (16,18) and the cross rail (20) define a relatively deep recessed section (22) disposed towards the leading edge of the body.

6. An air bearing slider as claimed in any preceding claim characterised in that the body is rectangular in plan.

7. An air bearing slider as claimed in any preceding claim characterised in that the flying height relative to said confronting planar surface is in the range of 8×10^5 to 2.8×10^4 mm (3×10^5 to 1.1×10^5 inch).

8. An air bearing slider as claimed in any preceding claim characterised in that the recessed section (22) has a depth relative to the surfaces of the rails (16,18,20) of 5×10^4 to 3×10^2 mm (2×10^5 to 1.2×10^3 inch).

9. An air bearing slider as claimed in any preceding claim characterised in that a trailing edge cross rail (40;44) comprises a plurality of transducer elements (32) for addressing tracks on the confronting planar surface.

10. An air bearing slider as claimed in claim 9 characterised in that the trailing edge cross rail (40;44) provides a full width close proximity sensor of media roughness on the confronting planar surface.

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11. An air bearing slider as claimed in any preceding claim characterised in that the positive pressure and negative pressure regions provide a net load of substantially zero across the surface of the body.

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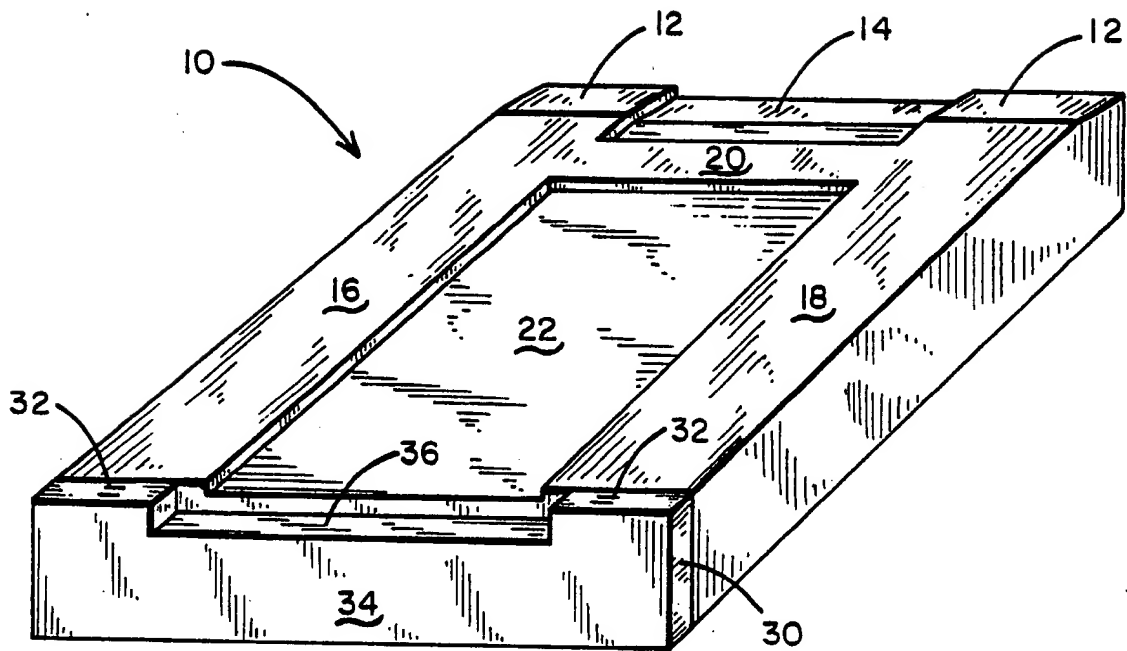
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PRIOR ART
Fig. 1

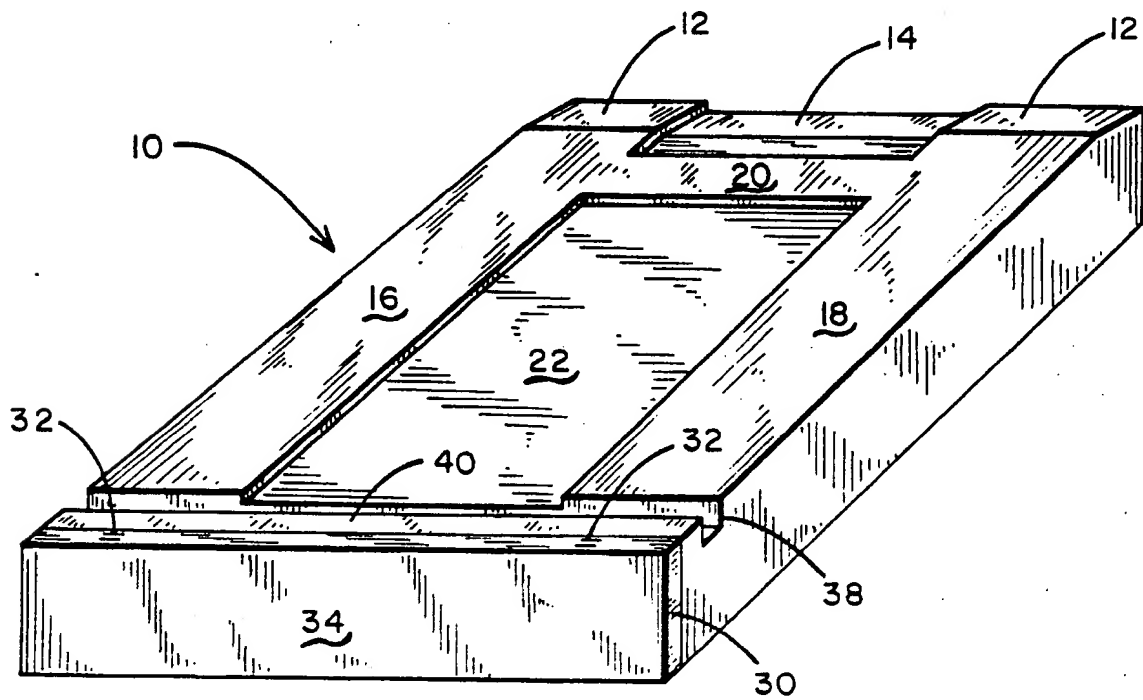


Fig. 2

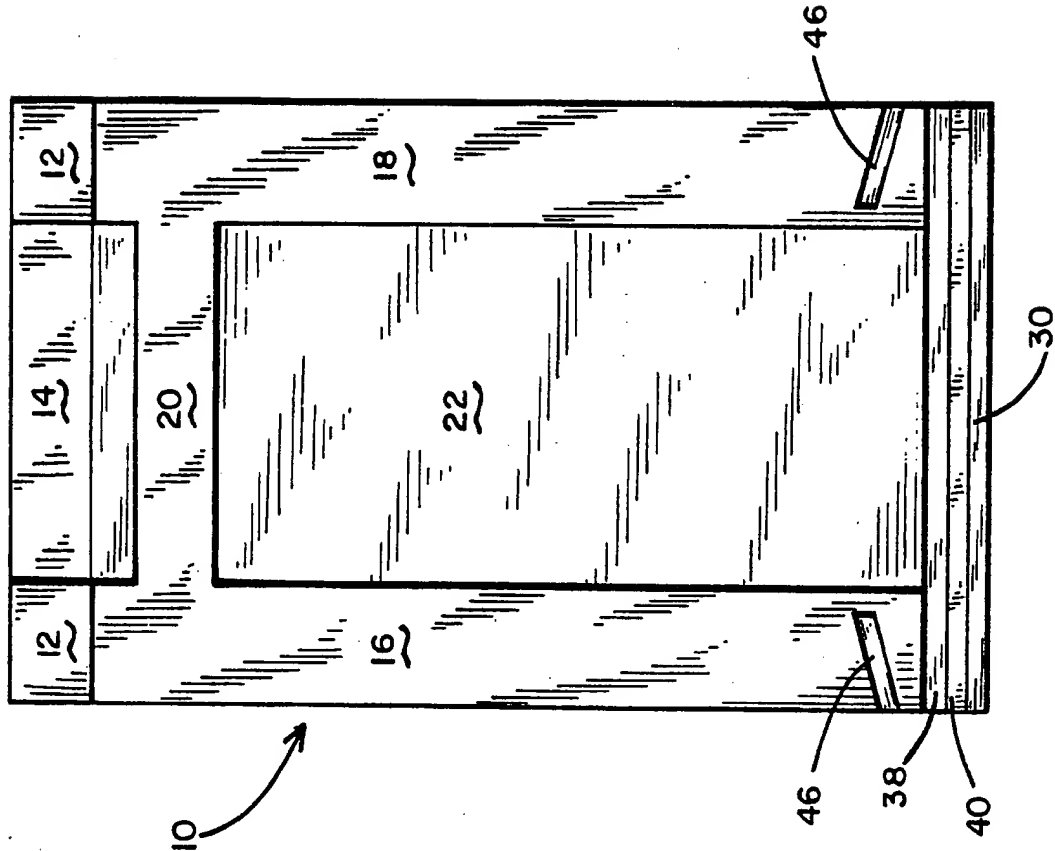


Fig. 3a

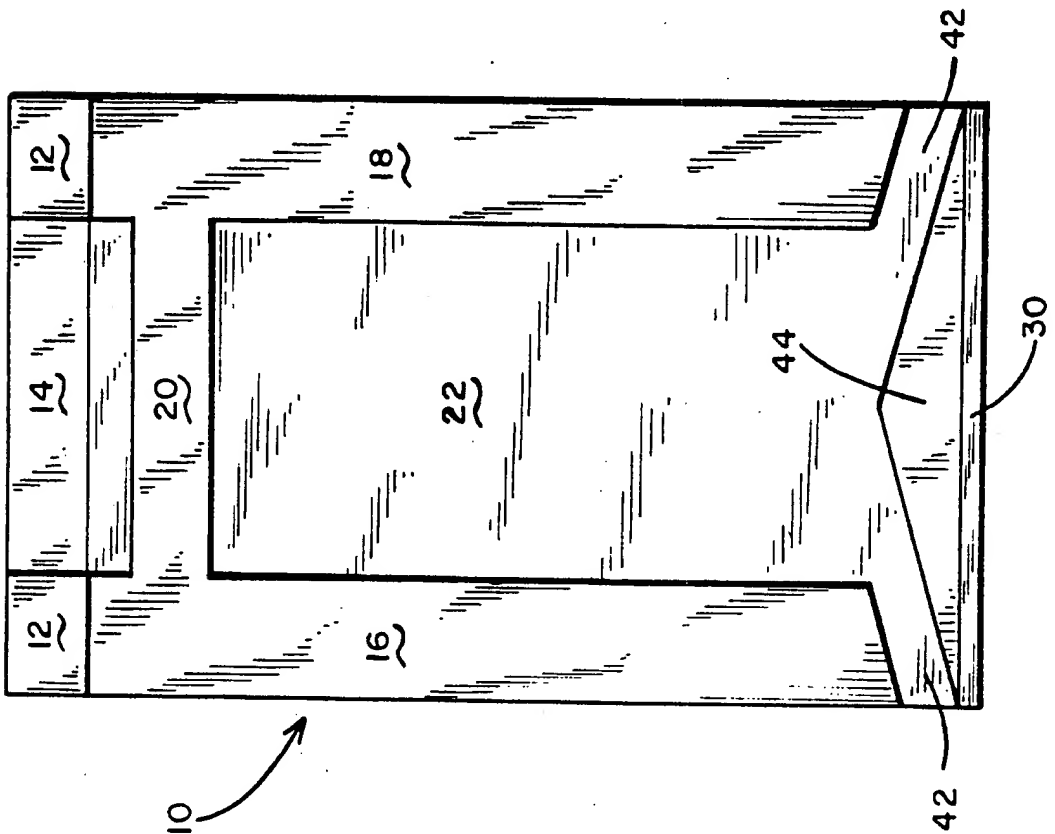


Fig. 3b

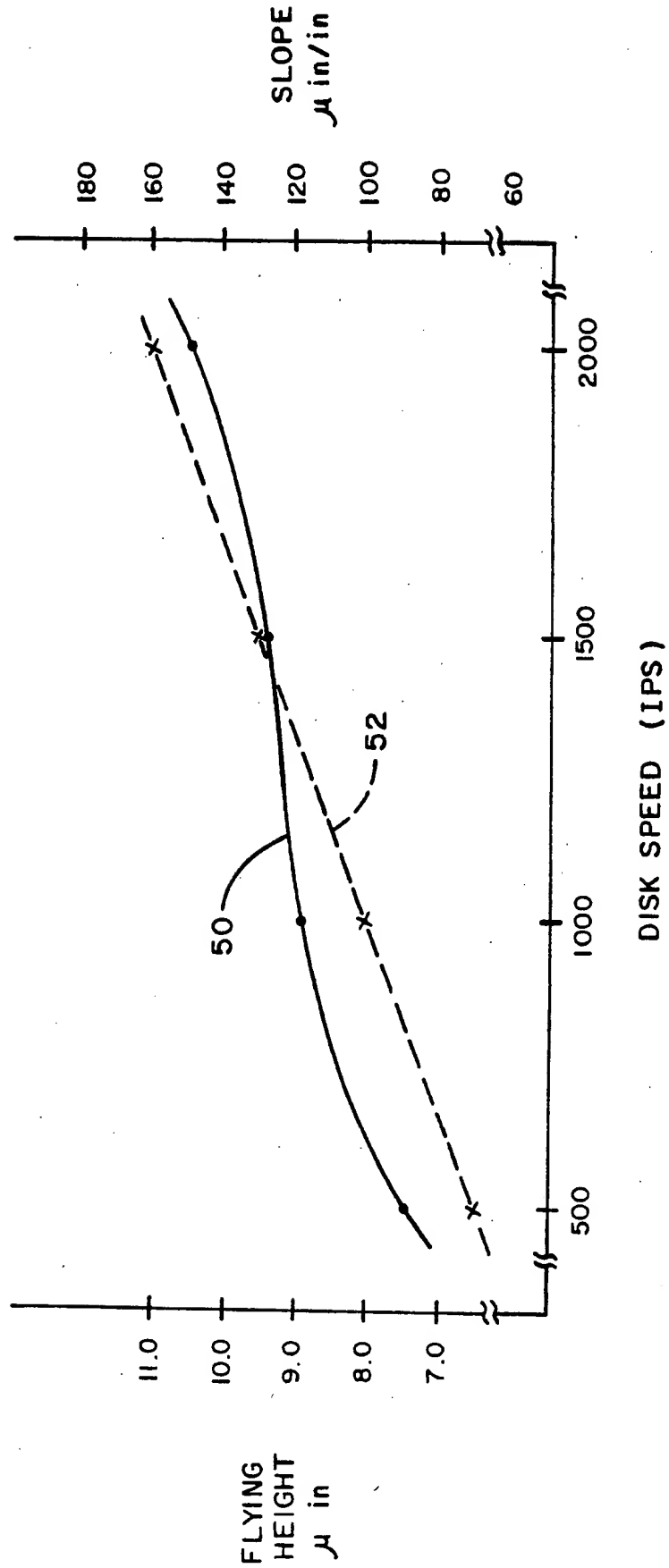


Fig. 4